Project Report: Cosmochemistry of Carbonaceous Meteorites

Lead Team:	***Arizona State University***
Project Title:	***Cosmochemistry of Carbonaceous Meteorites***
Project Investigators:	***Jack Farmer, Laurie Leshin***

Project Progress

In this grant period, Leshin and collaborators have concentrated on (1) modeling and publishing our data on the environmental history of carbonaceous chondrites and their associated pre−biotic organic molecules, and (2) obtaining new data in the exploration of the isotopic composition and distribution of carbon reservoirs on Mars.

Research conducted by Co−I Pizzarello this past year was largely devoted to the analyses of the Tagish Lake meteorite, a carbonaceous chondrite that fell in Canada in January of 2000. The meteorite's atmospheric entry was exceptional in many regards: it was detected by a Department of Defense satellite, a first in observation of fireball and recovery of dust and meteorite, the landing was a frozen lake of a sparsely populated area of Canada, and the meteorite was recovered fairly soon by a local resident who, aware of its identity, carefully wrapped it and kept it frozen. Although the scientific interest for a meteorite so rare has been great, all the pristine samples remain the property of the finder to date. This laboratory received half of the only ten−gram piece that the finder has given so far for "destructive" analyses. The study of Tagish Lake organic content, which was published (Pizzarello et al., 2001; Pizzarello and Huang, 2002), characterized both the soluble organic suite and the insoluble macromolecular carbon of this meteorite.

Work by Pizzarello also included continuing pursuit of the molecular, chiral, and isotopic characterization of non−racemic amino acids in carbonaceous chondrites. New data relevant to the understanding of amino acid enantiomeric excesses in meteorites were submitted for publication. These new results appear to discount the hypothesis that UV circularly polarized irradiation during meteoritic compounds formation was the sole cause of their asymmetry and instead suggest more complex processes in which the meteorite mineral phases may have intervened.

Highlights

- Preliminary measurements reveal that ALH84001 carbonates are highly variable in their carbon isotope composition, and that this composition correlated with oxygen isotopes.

- Magmatic phosphates in Martian Meteorites carry carbon from the Martina mantle to the surface. This mantle component is isotopically lighter than Earth's mantle but heavier than previous estimates, which were probably compromised by terrestrial contamination.

- Chemical characterization of the soluble and insoluble macromolecular carbon of the Tagish Lake carbonaceous meteorite, which fell on a frozen lake in Canada in January of 2000, revealed it to be compositionally unique in relation to other carbonaceous chondrites. This suggests alternative pathways for prebiotic chemical processes on the parent bodies of these important meteorites.

Roadmap Objectives

- ***Objective No. 1:*** Sources of Organics on Earth
- ***Objective No. 5:*** Linking Planetary Biological Evolution
- ***Objective No. 8:*** Past Present Life on Mars
- ***Objective No. 11:*** Origin of Habitable Planets

Mission Involvement

Mission Class*	***Mission Name (for class 1 or 2) OR Concept (for class 3)***	***Type of Involvement*** **
2	Mars Scout	Leshin is PI for this Scout proposal to provide the first Mars Sample return mission. The concept was selected for a 6 month feasibility study which has taken place over the past year. The project will be proposed to the Mars Scout Program on Aug. 1.

* Mission Class: Select 1 of 3 Mission Class types below to classify your project:
1. Now flying OR Funded & in development (e.g., Mars Odyssey, MER 2003, Kepler)
2. Named mission under study / in development, but not yet funded (e.g., TPF, Mars Lander 2009)
3. Long−lead future mission / societal issues (e.g., far−future Mars or Europa, biomarkers, life definition)

** Type of Involvement = Role / Relationship with Mission
Specify one (or more) of the following: PI, Co−I, Science Team member, planning support, data analysis, background research, instrument/payload development, research or analysis techniques, other (specify).

This Mars Scout proposal offers the opportunity for a first Mars sample return based on a unique mission design whereby a spacecraft (Sample Collection for Investigation of Mars (SCIM)) will pass through the upper atmosphere of Mars during the annual global dust storm cycle, collect suspended atmospheric dust with an aerogel−based sampling system, and return the sample to Earth. The system will be self−sterilizing because of high particle impact velocities and thus, not designed to sample organisms. However, the mineraological information that will be obtained from the detailed laboratory analysis of dust particles will provide important information about the composition of Martian surface materials, needed as context for the astrobiological exploration of the planet.

Cross Team Collaborations

Leshin collaborated with Bruce Jakosky (Univ. of Colorado team) on implications of the D/H ratios of martian meteorites for the volatile history of Mars. Leshin also initiated a project with Tom Ahrens at Caltech (part of Caltech/Jet Propulsion Laboratory (JPL) team) on shock devolatilization of water from extraterrestrial materials, a topic that has implications for (1) the interpretation of important measurements of Martian meteorites and (2) the delivery of water to planets. Pizzarello continued her collaborative studies of meteorites with George Cooper and others at NASA Ames on the Tagish Lake meteorite.